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1 **Global no net loss of natural ecosystems**

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28

29 **Abstract**

30 A global goal of No Net Loss (GNNL) of natural ecosystems or better has recently been
31 proposed, but such a goal would require equitable translation to country-level contributions.
32 Given the wide variation in ecosystem depletion, these could vary from Net Gain (for
33 countries where restoration is needed), to Managed Net Loss (in rare circumstances where
34 natural ecosystems remain extensive and human development imperative is greatest).
35 National contributions and international support for implementation also must consider non-
36 area targets (e.g. for threatened species) and socioeconomic factors such as the capacity to
37 conserve and the imperative for human development.

38

39 **Main text**

40 Momentum is building for an ambitious new commitment to be signed at the Conference of
41 the Parties to the Convention on Biological Diversity (CBD) in 2020 as a global framework
42 for nature conservation¹⁻⁴. Notable are calls for retention of half the Earth's natural
43 ecosystems^{5,6}, to be enshrined by 2030 as a target under the deal. Yet this leaves little 'room
44 to move'—approximately half the Earth's terrestrial ecosystems have already been lost⁷.
45 Nevertheless, complete cessation of anthropogenic impacts on natural ecosystems is
46 infeasible, given the imperative for socioeconomic development where current levels of
47 human development are low⁸. Conservation that ignores such differences among nations is
48 likely to be unjust⁹.

49 In this context, a goal of global No *Net* Loss (GNNL) of natural ecosystems is likely the most
50 ambitious target that society can realistically achieve^{10,11}, at least by 2030. Such a goal allows
51 for losses in some places and gains in others, which, taken together, ensure no further net
52 decline of natural ecosystems, benefitting the species and people which rely upon them¹².
53 GNNL implies an absolute cessation of decline in net terms—a key distinction from the
54 relative 'NNL' that characterises biodiversity offset policies¹³.

55 It is far from trivial to translate a GNNL goal to effective policy mechanisms and mitigation
56 approaches at the national level; indeed, the problem is akin to dividing humanity's 'carbon
57 budget' equitably^{14,15}. Here, we examine how different countries might set goals for retention
58 and restoration as part of a contribution to achieving GNNL of natural ecosystems, using
59 terrestrial ecosystems as an example.

60 Translating a GNNL goal to a blanket requirement for each nation to achieve NNL would
61 clearly be inappropriately coarse. Instead, a GNNL target would act as an umbrella for a
62 range of minimum net outcome goals adopted by each country as their respective
63 contributions to GNNL (Fig. 1). Some countries support natural ecosystems across almost
64 their entire extent—10 have more than 75% of original natural ecosystems according to the
65 latest published human footprint¹⁶ (e.g. Suriname and Canada Fig. 1; see Methods for more
66 detail), while others retain close to none of their original natural ecosystems in reasonable
67 condition (68 countries including France, Italy and India have <5% remaining; Fig. 1).
68 Countries also vary tremendously in the imperative to convert or degrade those ecosystems in
69 the pursuit of needed economic development, and in their capacity to protect and restore
70 ecosystems. So, under a GNNL commitment, some countries might focus on restoring earlier
71 losses, while others might further deplete their remaining ecosystems. Thus, some countries
72 might commit to Net Gain, some to NNL, and in some circumstances, controlled loss, or
73 drawdown, of ecosystems (here termed Managed Net Loss).

74 Information about depletion of natural ecosystems can help frame both country-level
75 conservation goals, and policy mechanisms for achieving those goals. For example, even
76 NNL is likely to be inadequate to conserve threatened species and functioning ecosystems for
77 countries whose natural ecosystems are most severely depleted. Therefore, for such countries,
78 Net *Gain* in the extent of their natural ecosystems is likely to be essential. For example, the
79 UK has only 6% of ecosystems with a Human Footprint of <4 remaining (a threshold used as
80 a proxy for ecosystem intactness⁷). The UK government recently proposed biodiversity Net
81 Gain as a requirement for new development projects¹⁷. Similarly, France has committed to
82 zero net conversion of natural land¹⁸. On the other hand, those countries with largely intact
83 remaining ecosystems (e.g. Suriname, Gabon) may, in some circumstances, be able to accept
84 further limited and controlled depletion ('Managed Net Loss') (Fig. 1). However, even if all
85 countries with less than 25% of natural ecosystems remaining adopt Net Gain and seek to
86 double the extent of those ecosystems through restoration, this would only contribute 4% to
87 global ecosystem extent. Conversely, even a small percentage of net loss from countries with
88 extensive remaining natural ecosystems, such as Australia and Brazil (5,535,401 km² and
89 4,643,615 km², respectively), would shift a very substantial restoration burden to other
90 countries, if GNNL is to be achieved.

91 Even within countries that retain similar amounts of natural ecosystems, variation in
92 depletion among different ecosystems can be lower (e.g. Norway, where retention of all its

different ecosystem types is similarly high) or higher (e.g. Chad, where some ecosystems are much more depleted than others). In such cases, approvals for unavoidable losses of less-depleted ecosystem types might be tied to requirements to restore other, more-depleted ecosystems, using compensatory policy mechanisms like biodiversity offsetting^{19,20}. Further complexity is introduced by the fact that some ecosystems may be extensive within a country, but globally rare; conversely, others are highly-depleted at a country level, yet globally common. Therefore, both country-level goal-setting, and trading losses for gains among different ecosystems within a country, must reflect this variation to ensure all ecosystem types can be adequately conserved.

We use the retention of terrestrial natural ecosystems to illustrate the complexity of translating GNNL to country-level goals, and propose that a similar exercise could consider the translation of the concept to the marine realm, or indeed to non-political units such as ecoregions. However, area-based retention is only one type of target that must be set for biodiversity to be adequately conserved. For example, the number of species listed as threatened with extinction does not correlate strongly with the depletion of natural ecosystems within a country (Pearson's $R = 0.17$; Figure 1a), though species decline often lags behind habitat loss²¹. Therefore, further ecosystem losses even from countries with relatively extensive natural systems could have a disproportionately negative impact in the most diverse but imperilled places (e.g., Brazil; 55% ecosystems remaining but 290 globally-threatened species of birds, mammals and amphibians).

A purely biophysical basis for conservation goal-setting in a country ignores important socioeconomic realities, which may further modify appropriate relative contributions of countries to a GNNL goal. Countries vary enormously in their levels of human development; people's basic needs in many countries are not currently being met¹². Rapid economic growth for those at the bottom of the global wealth rankings is the most important goal for governments in many such countries and is essential from a human rights perspective. The countries with the most severe ecosystem depletion (and therefore requiring, in principle, biodiversity Net Gain) include many countries with the lowest Human Development Index (HDI) values (e.g. numerous African countries) (Fig. 2). Given that converting ecosystems can contribute to much needed development, and significant amounts of ecosystem degradation in poorer countries has contributed to fuelling economic growth in richer countries²², it is unrealistic as well as unjust for goals to be set without socio-economic circumstances being considered. Addressing these equity implications, while also recognising

the fundamental role of nature in supporting achievement of the Sustainable Development Goals¹², will also be essential to secure support for a GNNL commitment.

Given that globally, biodiversity loss already exceeds safe levels²³, NNL at the country level might be the minimum acceptable standard for wealthy, developed countries where standards of living are already high (e.g. Australia, Canada; Fig. 2). We suggest their conservation goals should be set such that further degradation and loss of ecosystems is halted—at least in net terms. This may require radical solutions including moving away from the paradigm that economic growth is always desirable⁹.

Countries with low HDI are more likely to face further pressure on their natural ecosystems to facilitate urgently-needed economic development. Therefore, even where the level of depletion of natural ecosystems implies a NNL goal, Managed Net Loss may be unavoidable for such countries (Fig. 2), at least temporarily²⁴. Countries with a low HDI may reasonably expect support from the international community to deliver on their contribution to a GNNL goal. Unfortunately, weak governance in some low HDI countries discourages such investment²⁵ and can limit the effectiveness of any development support²⁶ or of any in-country mechanisms to compensate for biodiversity losses. For example, many of the countries to which assistance may need to be provided score poorly on the Corruption Perceptions Index (Fig. 2). Achievement of global biodiversity conservation arguably is most sensitive not to the global goals and targets that are agreed, but to how well such complex challenges to their implementation are addressed²⁷.

Our framework provides guidance on the principles through which different countries could identify appropriate respective contributions toward a global goal of NNL of biodiversity. Any agreed set of contributions must tackle the reality of both biodiversity depletion, its causes, and global inequity in both ongoing pressures and capacity to respond to them. Goals must be transparently managed to avoid the task falling inequitably upon the world's poorest countries, while recognising that development at the expense of biodiversity is unsustainable²⁸.

Loss without limit is the paradigm under which natural ecosystems are currently being destroyed³. The need to clarify the overarching goal of the CBD and sharpen our commitments to retain, restore, and protect natural ecosystems was underscored resoundingly by the recent release of the IPBES global assessment²⁹. So, as the focus turns to setting post-2020 conservation targets under the CBD, calls to dramatically increase their ambition^{1,30} and

to set explicit nature retention targets³ must be heeded—and a pathway to translate them to country-level contributions laid out. A GNNL goal sets a limit to the loss we—and biodiversity—can tolerate, while allowing for human development where it is most urgently needed. Any basis for country-level commitments to a GNNL goal must reflect the substantial variation among countries in the level of depletion of their natural ecosystems—but also the degree to which capacity to conserve and the imperative for human development varies globally.

Methods

We used the depletion of natural ecosystems as one proxy for biodiversity loss, and the global Human Footprint 2009 dataset³¹ as an indicator of this depletion. The Human Footprint is a comprehensive representation of anthropogenic threats to biodiversity, which cumulatively accounts for eight human pressures—built environments, crop lands, pasture lands, human population density, night lights, railways, major roadways, and navigable waterways³¹. It is mapped across the terrestrial surface of the globe at a 1 km² resolution, on a scale of 0 (lowest Human Footprint) to 50 (highest Human Footprint). Human Footprint values of 0-3 are representative of land that is largely devoid of infrastructure and development (although may support sparse human populations)^{7,32}. We therefore considered areas with a Human Footprint value of ≥ 4 to be transformed – in other words, no longer supporting a natural ecosystem (as per Watson, et al.⁷).

For 170 countries (for which data were also available for all measures), we calculated the area of the country that is mapped with Human Footprint values of 0-3, as a proportion of the area of the country (for which Human Footprint mapping was available). This represented our measure of the proportion of the original natural ecosystems remaining in each country. We also calculated the variance in depletion of specific natural ecosystem types in each country. To do this, we used the map of global terrestrial ecoregions³³, to represent the broad ecosystem types that do or would have naturally occurred in each country. We calculated the loss of each ecoregion type per country, by overlaying the Human Footprint map (value ≥ 4). To calculate the variation in depletion among ecoregion types within each country, we used the Gini coefficient – a metric frequently used to indicate dispersion within a frequency distribution. Although most commonly used as an index of income inequality, it can be used as an index of inequality for disparate datasets; a value of 0 indicates all values are identical

and 1 indicates extreme disparity among values. All GIS analysis was undertaken using ArcMap6.1, with spatial datasets projected to a Mollweide coordinate system.

To explore the extent to which countries differ in their biophysical context, we plotted the proportion of the original natural ecosystems remaining in each country against the variance in depletion of natural ecosystems. We also considered two other measures of the status of a country's biodiversity: the number of species listed as threatened under the IUCN Red List of Threatened Species (restricted to fully assessed taxa only, as of November 2018: mammals, birds, amphibians; note that most taxa are poorly known, so this too is a partial measure); and the total area (km²) of natural ecosystems remaining in each country.

To examine how countries varied in environmental *and* socioeconomic contexts, we incorporated two further datasets into our analysis. We used the 2017 Human Development Index (HDI)³⁴ as a representation of key elements of human development at the national level. This composite metric subsumes indices relating to life expectancy, education and per capita income. We also considered the 2017 Corruption Perceptions Index (CPI)³⁵, which represents relative public sector corruption levels of nations as perceived by experts and businesspeople, and has been linked with the strength of a nation's democratic institutions³⁶. We plotted these variables as they relate to a nation's level of depletion of ecosystems, to examine how variation in a country's socioeconomic factors potentially affect its capacity to contribute to a goal of GNNL.

Author contributions

MM, JPGJ, JEMW and JSS led the writing. JSS led the data analysis. All authors developed the central concepts collaboratively, and wrote and edited parts of the manuscript.

Data availability

All datasets used in this analysis are available via the citations identified in the Methods section. The raw data used to create Figure 1 and Figure 2 are available in Supplementary Table 1.

Code availability

No custom code was used.

220

221 **Competing interests statement**

222 LB, FQ and AvH receive income from commercial contracts for consultancy services related
223 to the development and implementation of biodiversity offset policies.

224

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231

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326

327 **Figure legends**

328 **Fig. 1.** Potential contributions of countries to GNNL. The proportion of natural ecosystems
 329 (Human Footprint value <4) remaining per country varies enormously, as does variation in
 330 the depletion among different ecosystems (Gini coefficient; see Methods). The minimum
 331 country-level contribution to a GNNL goal must reflect this, as well as the absolute area of
 332 natural ecosystems remaining (Fig. 1b). Ecosystem depletion must be considered alongside
 333 other factors in setting targets; e.g., the number of threatened species according to the IUCN

334 Red List of Threatened Species (for fully-assessed taxa only - mammals, birds and
335 amphibians) relates only weakly to retention of ecosystems ($R = 0.17$; d.f. 169; $P = 0.0279$; R
336 version 3.5.1; Fig. 1a).

337

338 **Fig. 2.** The degree of human development should affect minimum country-level contributions
339 to achievement of GNNL, such that high HDI countries commit to at least country-level
340 NNL. Bubble size reflects the Corruption Perceptions Index (2017) for each country; see
341 Methods.

Minimum contribution
to global NNL goal



